SCIENCE.

FRIDAY, JUNE 4, 1886.

COMMENT AND CRITICISM.

IN A RECENT NUMBER of the *Revue internationale de l'enseignement*, M. Breal, who has written before on educational topics, has an essay on the methods of acquiring foreign languages. Among some old considerations of value, he adds the less well-known remark, that, when a person goes to a foreign country to 'learn the language,' he rarely succeeds. But if he goes to pursue some definite profession or business, — M. Breal suggests banking at Frankfort, the book-trade at Leipzig, and brewing at Munich, among others, — then he acquires the language very rapidly as well as very thoroughly. The reason for this is plain enough: it is the substitution of natural for scholastic methods. And nature, being the better teacher, comes out ahead. In the former case, dictionaries and grammars figure largely; while, in following M. Breal's suggestions, the phrases of ordinary conversation, as well as the terminology of some particular calling, become part of the student's daily experience from the first. The hint is a valuable one, and it might save time and money, to say nothing of a discouraged spirit, to the numerous young men and women who go to Germany, France, and Italy each year to 'learn the language.'

IN THE DEATH, on May 16, of the aged German historian, the world has lost a scholar who has done as much as, if not more than, any one else for the extension of scientific method, and for the application to history of those rules and tests which mark the nineteenth century as pre-eminently the era of science. Born in 1795, when the reign of terror was hardly passed, and when the metaphysical notions as to the theory of the state and the rights of man which had been formulated by Bodin, Grotius, Montesquieu, Voltaire, and Rousseau, were finding their logical outcome in anarchy, Ranke grew up in a period of transition. The wave of constitutionalism was gathering a force to which even the reaction from the revolutionary excesses of the commune, aided by the holy alliance, could be but a temporary check. With a genius that detected the chain of causation amid a complicated mass of detail, with an exactness and an accuracy that made even the smallest event of importance, and with a power of lucid, graphic statement which attracted and interested while it instructed, Ranke was born a scientific historian. He appreciated to the full the meaning of the contemporary development, but with true historical instinct he turned to the elucidation of that previous period of transition from feudalism to absolutism which is the key to the history of western Europe in the fifteenth, sixteenth, and seventeenth centuries. In this field he was the acknowledged master. In addition to his own magnificent labors, we owe to Von Ranke the *seminarium*, that peculiarly scientific department of university work. And it is from him that Waitz, Giesebrecht, Von Sybel, George Bancroft, and a host of lesser historians have drawn their inspirations.

FABRY'S AND BARNARD'S COMETS, the two that have been with us since last December, have now disappeared from view in the northern hemisphere. Very few astronomers appear to have seen these comets under the most favorable circumstances. Mr. T. W. Backhouse, however, reports that on April 26 he followed the tail of Fabry's comet to a distance of thirty-eight degrees; and Barnard's comet he found on May 1 had two tails, the principal one four and a half degrees in length. To replace these comets we have three new ones discovered by Mr. Brooks, on April 27 and 30, and May 22, respectively. They are all fairly bright for what are called 'telescopic' comets. The calculated elements show that the first reaches its nearest point to the sun on June 6, and is increasing slightly in brightness: the second comet is decreasing in brightness, having passed its perihelion on May 4.

HEALTH OF NEW YORK DURING APRIL.

THE total population of New York on April 1 was estimated at 1,428,898, and is believed to be increasing at the weekly rate of 799.

The total number of deaths from all causes was 2,965, or about 99 each day. Comparing this with

the same number of days in March, there was a reduction representing the saving of 290 lives, and this not taking into account an increase in the population of more than 3,000 souls.

In March the largest number of persons succumbed to disease on the 31st, there being on that day 137 deaths recorded; on the 30th of April the maximum limit was reached, amounting to but 124 deaths.

The deaths of children under five years of age during March were 1,221, and in April but 1,075; and yet diarrhoeal diseases carried off in April 56 persons, and only 32 in the preceding month. Scarlet-fever caused a mortality of 49 this month, as compared with 42 in March. The lines in the chart representing scarlet-fever and the diarrhoeal diseases, which for two months have nearly coincided, now begin to diverge, and the separation will be more and more marked as the season advances. The increase of deaths from diarrhoeal diseases appears to be pretty evenly distributed throughout the month, and not very perceptibly increased in any one period over another. The largest number of deaths from diseases of this nature in any one day was 5, on the 22d. The week in which this occurred was characterized by high temperatures, 81°, 74°, 74°, 81°, 84°, and 83° being the maxima for six consecutive days beginning with the 19th; and during this period there were 16 deaths from this class. The next largest number of deaths was 4, on the 11th inst.; and on six consecutive days of that week the maxima reached by the thermometer were respectively 70°, 52°, 64°, 68°, 69°, and 67°, and the recorded deaths were 14.

This is an interesting comparison, and would seem to show that there are other influences at work in the causation of diarrhoeal diseases than an elevation of temperature at one part of the day. On these days, when the thermometer was ranging from 74° to 84° in the afternoon, it was at other parts of the day much lower, sometimes as low as 48°. It is the high temperature continued throughout the greater part of the twenty-four hours, and repeated day after day, as occurs in July and August, which produces such fearful ravages among the inhabitants of the large cities. Especially is this destructive influence marked when the air is laden with moisture. A study of the accompanying chart will show, that, at the time when these high temperatures occurred, the air was comparatively dry; on the 23d inst., when the maximum temperature was 84°, the humidity was but 60, saturation being 100. That this is an important element in the problem is not to be overlooked. It is a matter of common experience that a temperature of 90° with a dry atmosphere can be more comfortably borne than one of 80° with the air saturated with moisture. In the one case evaporation from the body is rapid, resulting in a cooling of the surface; in the other it is impeded, or seriously interfered with.

Consumption and diphtheria show for April, as compared with March, a slight decrease in mortality.

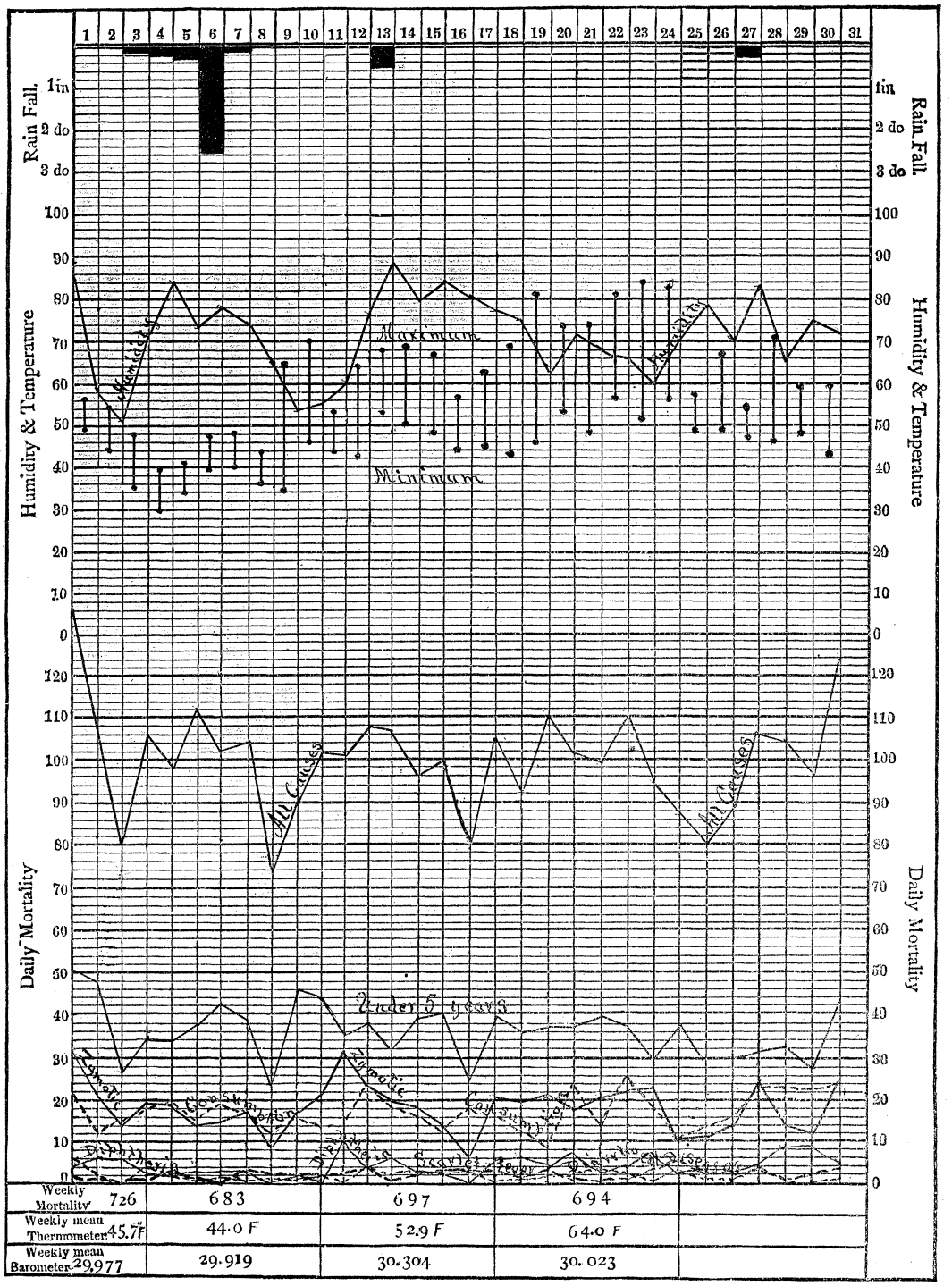
The mean temperature for the month was 52.87°, that for March having been 37.60°. The maximum was on the twenty-third day, the thermometer then registering 84°. This is the highest recorded in the month of April since 1871. 62° was the highest point reached by the mercury during March: its lowest point in that month was 8°, while during April at no time was it more than two degrees below freezing.

While the number of days upon which rain fell was but seven, rather less than the average for a considerable number of years, yet the total amount of water which fell was 3.85 inches, considerably above the average amount for the same period. On the 4th of the month one-quarter of an inch of snow fell, and three-quarters of an inch on the day following. In the corresponding month of 1885, there were several flurries of snow, the amount being too small to accurately measure. Snow is not a frequent visitor in the month of April: in the year 1870 it fell to the depth of two inches and a half; in 1875 no less than thirteen inches and a half are recorded; and in the years 1882 and 1883 there was in each one half-inch. With these exceptions, no snow has fallen in April during the past fifteen years. From a meteorological point of view, April, 1886, was an exceptional month.

SYMPATHETIC VIBRATIONS OF JETS.[1]

AFTER a brief historical notice of the observations of Savart, Masson, Sondhauss, Kundt, Laconte, Barret and Tyndall, Decharme, and Neyreneuf, on the sympathetic vibrations of jets and flames. the author described his own experiments. Attention was directed to the subject by the accidental observation that a pulsating air-jet directed against a flame caused the latter to emit a musical sound. The pitch of this sound depended solely on the rapidity of the jet-pulsations, but its intensity was found to increase in a remarkable way with the distance of the flame from the orifice. In order to study the phenomenon, air was allowed to escape against the flame from a small orifice in the diaphragm of an ordinary telephone, the chamber behind the diaphragm

[1] Abstract of paper read before the Royal society, April 28, by Chichester A. Bell.



Weekly Mortality	726	683	697	694	
Weekly mean Thermometer	45.7F	44.0 F	52.9 F	64.0 F	
Weekly mean Barometer	29.977	29.919	30.304	30.023	

being placed in communication with a reservoir of air under gentle pressure (fig. 1). Vibratory motions being then excited in the diaphragm, by means of a battery and a microphone or rheotome in a distant apartment, the discovery was made that speech as well as musical and other sounds could be quite loudly reproduced from the flame. Certain observations led the author to suspect that motion of the orifice, rather than compression of the air in the chamber, was the chief agent in the phenomenon; and, in fact, precisely similar results were obtained when a light glass jet-tube was cemented to a soft iron armature, mounted on a spring in front of the telephone magnet (fig. 2).

Experiment also showed that an air-jet at suitable pressure directed against a flame repeats all sounds or words uttered in the neighborhood (fig. 3). Except, however, where the impressed vibrations do not differ widely in pitch from the normal vibrations of the jet (discovered by Sondhauss and Masson), these effects are likely to escape notice owing to the inability of the ear to distinguish between the disturbing sounds and their echo-like reproduction from the flame.

In these experiments the primary action of the impressed vibrations was undoubtedly exerted on the air-jet; but a singular and perplexing fact was that no sound, or at best very faint sounds, could be heard from the latter when the flame was removed, and the ear, or the end of a wide tube connected with the ear, was substituted for it. Suspecting, finally, that the changes in the jet, effective in producing sound from the flame, must be relative changes of different parts of it, the author was led to try a very small hearing-orifice, about as large as the jet-orifice (fig. 4). The results were most striking. By introducing this little hearing-orifice into the path of a vibrating air-jet, the vibrations can be heard over a very wide area. Close to the jet-orifice they are so faint as to be scarcely audible; but they increase in intensity in a remarkable way as the hearing-orifice is moved away along the axis of the jet, and reach their maximum at a certain distance. Experiments with smoked air showed that this point of maximum sound is that at which the jet loses its rod-like character, and expands rapidly: it has been named the 'breaking-point,' because just beyond it the sounds heard from the jet acquire a broken or rattling character, and at a greater distance are completely lost. The distance of the breaking-point from the orifice diminishes as the intensity of the disturbing vibrations is increased, and also depends to some extent on their pitch and on the velocity of the jet. With orifices of from 1 to 1.5 mm. in diameter, it usually varies from 1 to 6 cm. The vibrations of an air-jet may also be heard at points not situated on the axis; but they are always most intense along the axis, and become rapidly fainter as the distance from it increases.

With glass jet and hearing-tubes, and a light gas bag to serve as reservoir, these experiments are easily repeated; but simple apparatus for more careful experiments is described. The author's general conclusions from his experiments and those of others are as follows:—

A jet of air at moderate pressure (below 10 mm. of water) from an orifice from 1 to 1.5 mm. in diameter, forms a continuous column for a certain distance, beyond which it expands and becomes confused.

Any impulse, such as a tap on the jet support, or a short and sharp sound, causes a minute disturbance to start from the orifice. This disturbance increases in area as it progresses, and finally causes the jet to break. By directing the jet against a flame or a hearing-orifice, it is readily perceived that such disturbances travel along the jet-path with a velocity which is not that of sound in air. In fact, the sound heard in the ear-piece resembles an echo of the disturbing sound.

The disturbances produced by sounds of different pitch travel along the jet-path with the same velocity. This is evident, since otherwise accurate reproduction of the complex vibrations of speech at a distance from the orifice would be impossible. This velocity is much less than that of sound in air, and is probably the mean velocity of the stream.

A vibrating air-jet playing into free air gives rise to very feeble sounds, but these sounds are much intensified when the jet impinges on any obstacle which serves to divide it into two parts. Of such arrangements, the best is a perforated surface, the orifice being placed in the axis of the jet.

A jet of air at low pressure responds to and reproduces only sounds of low pitch. Sounds above a certain pitch, which depends on the pressure, either do not affect it or are only faintly reproduced.

At pressures between 10 and 12 mm. of water, an air-jet reproduces all the tones of the speaking voice, and those usually employed in music, with the exception of very shrill or hissing noises. When the pressure in the reservoir equals about 13 mm. of water, hissing sounds are well reproduced, while sounds of low pitch become fainter. At higher pressures, up to about 25 mm. of water, shrill or hissing noises produce very violent disturbance, while ordinary speech tones have little effect. But at these pressures sounds of high

pitch frequently cause the jet to emit lower sounds of which they are harmonics.

In general a pressure of about 12 mm. of water will be found most suitable for reproducing speech or music. Under this condition the jet is very sensitive to disturbances of all kinds, and will reproduce speech, music, and the irregular sounds classified as 'noises.'

It must be understood that the pressures here given are only suitable for jets of not too small diameter. When the diameter of the orifice is only a small fraction of a millimetre, the above limits may be much exceeded, since the velocity of efflux no longer depends solely on the pressure.

A jet of air escaping from a perfectly circular orifice does not vibrate spontaneously so as to emit a musical sound; but musical vibrations may be excited in it by the passage of the air on its way to the orifice through a resonant cavity, or through any irregular constriction.

An air-jet impinging on any obstacle, such as a flame, frequently vibrates spontaneously, if the obstacle is at sufficient distance and of such a nature as to diffuse the disturbances produced by impact, or throw them back on the orifice. This constitutes one of the chief objections to the use of a flame as a means of rendering audible the vibrations of a jet. The disturbances excited in the surrounding air by the impact of the stream upon it are so intense as easily to react on the orifice. When, therefore, the jet is thrown into any state of vibration, it tends to continue in the same state, even after the exciting sound has ceased.

A jet of air usually responds most energetically to some particular tone or set of related tones (Sondhauss). Such a particular tone may be called the jet fundamental. The practical inconvenience arising from this may be diminished by raising the air-pressure until the jet fundamental is higher than any of the tones to be reproduced.

When a flame and an air-jet meet at right angles, vibrations impressed upon the flame-orifice also yield sound. The conditions of pressure, etc., are somewhat different; but the changes produced at the orifice grow in the same way as those in an air-jet. The best results are obtained when a gentle current of air is directed from a wide tube just below the apex of the blue zone.

It is difficult, at first sight, to account for the fact that a vibrating jet gives rise to sound only when it strikes upon some object which divides it into two parts. The following experiments, however, in some sense explain this. The relative normal velocity at different points in the stream may be measured by introducing into its path the open end of a capillary tube which is connected with a water manometer. This velocity diminishes continuously along the axis from the orifice to the breaking-point, and also diminishes continuously from any point of the axis outwards towards the circumference. Now, a sudden disturbance communicated to the air at the orifice will be found to produce a fall in velocity along the axis of the jet, but a rise in velocity along its extreme outer portions. It thus appears that the changes along the axis and along the circumference, produced by a disturbance, are of opposite character. When the jet plays into free air, these opposing changes neutralize each other in the main; but this interference is prevented when the jet strikes upon any object which serves to divide it.

When a vibrating air-jet plays against a small flame, the best sounds are heard when the stream strikes the flame just below the apex of the blue zone. At the plane of contact an intensely blue flame ring appears, and this ring vibrates visibly when the jet is disturbed. The production of sound from it doubtless depends on changes in the rate of combustion of the gas. This may be proved by inserting into the ring a fine slip of platinum, connected in circuit with a battery and a telephone (fig. 5). When the jet is thrown into vibration, the consequent variations in the temperature of the platinum affect its conductivity, and hence a feeble reproduction of the jet-vibration may be heard in the telephone.

To Savart we are mainly indebted for our knowledge of the sympathetic vibrations of liquid jets. This physicist showed that a liquid jet always tends to separate into drops at a distance from the orifice in a regular manner; and that this tendency is so well marked, that when the jet strikes upon any object, such as a stretched membrane, so arranged that the disturbances caused by impact may be conducted back to the orifice, a definite musical sound is produced. The pitch of the sound, or the number of drops separated in a given time, varies directly as the square root of the height of liquid in the reservoir, and inversely as the diameter of the orifice. Savart further showed that external vibrations impressed upon the orifice may act like the impact disturbances, and cause the jet to divide into drops. Impact on a stretched membrane may then cause the reproduction as sound of the impressed vibrations. The tones capable of producing this effect were considered to lie within the limits of an octavo below and a fifth above the jet normal.

The author has found, however, that jets of every mobile liquid are capable of responding to

FIG. I.

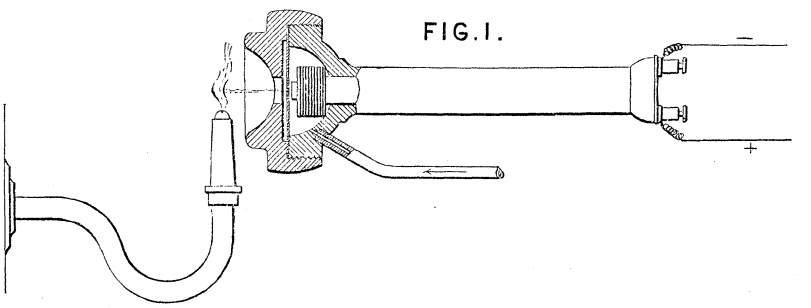


FIG. II.

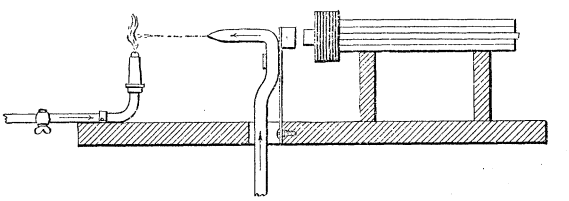
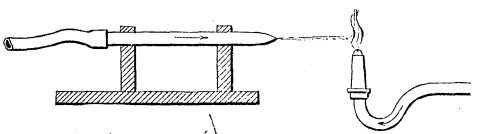


FIG. III.



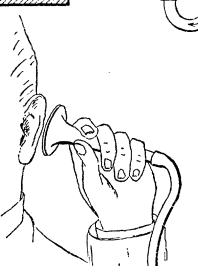


FIG. IV.

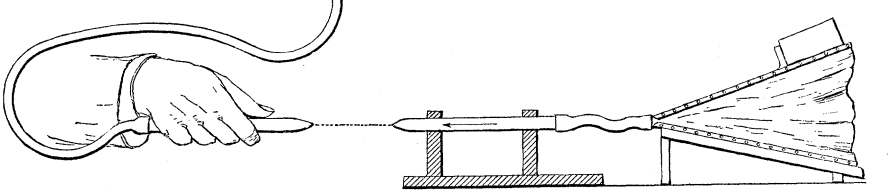


FIG. V.

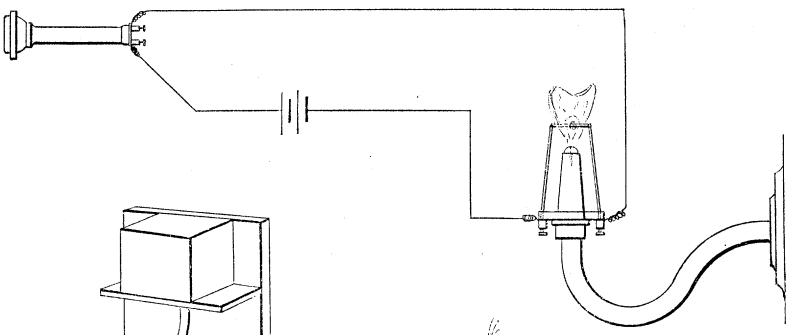


FIG. VI.

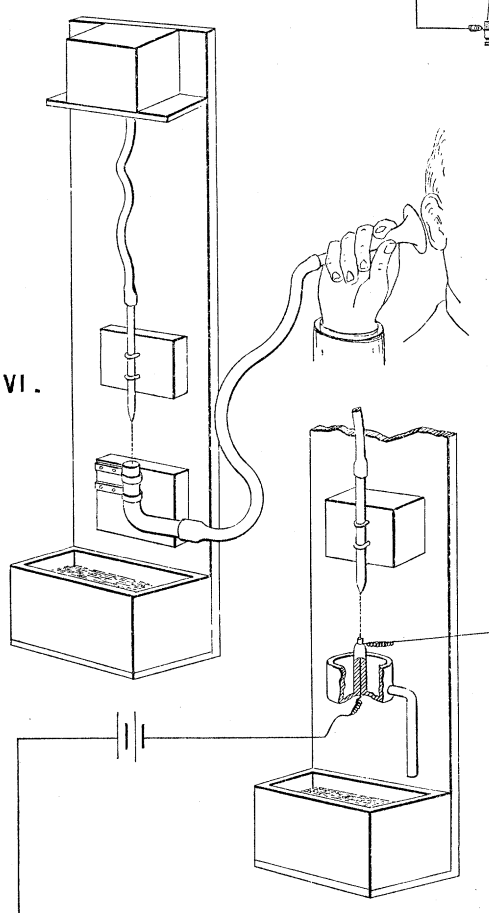
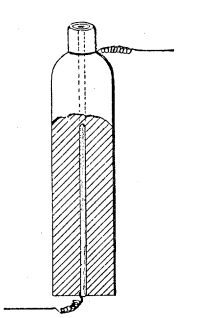


FIG. VII. & VIII.



and reproducing all sounds whose pitch is below that of the jet normal, as well as some above; and that the timbre or quality of the impressed vibrations is also preserved, provided that the jet is at such pressure as to be capable of readily responding to all the overtones which confer this quality.

Other essential conditions for perfect reproduction are, that the receiving-membrane should be placed at such distance from the orifice that the jet never breaks into drops above its surface, and that it should be insulated as carefully as possible from the orifice.

In order to assist the action of aerial sound-waves on the fluid, it is advisable to attach the jet-tube rigidly to a pine sound-board about three-eighths of an inch thick. The surfaces of the board should be free, otherwise it may be supported in any way. The receiving-membrane is formed by a piece of thin sheet-rubber tied over the end of a brass tube about three-eighths of an inch in internal diameter. A wide flexible hearing-tube furnished with an ear-piece is attached to the brass tube. The jet-tube is connected with an elevated reservoir by an india-rubber pipe (fig. 6).

With an apparatus of this kind, and a tolerably wide jet-tube having an orifice about 0.7 mm. in diameter, a pressure of about 15 decimetres of water is required to bring the jet into condition to respond to all the tones and overtones of the speaking voice (except hissing sounds) and those employed in music. At a somewhat higher pressure it will reproduce hissing sounds. It is not easy for an untrained ear to distinguish between the disturbing sounds and their reproduction by the jet, when both are within range of hearing. Vibrations may, however, be conveyed to a jet from a distance in a fairly satisfactory way by attaching one end of a thin cord to the jet-support, and the other to the centre of a parchment drum. The cord being stretched, an assistant may speak, sing, or whistle to the distant drum. Other devices for conveying vibrations from a distance are described.

Now, when the jet is disturbed in any way, and the receiving-membrane is introduced into its path close to the orifice, scarcely any sound can be heard in the ear-piece; but, if the membrane be moved away from the orifice along the path of the jet, the sounds become gradually louder, until at a certain distance (which varies both with the character of the orifice and the intensity of the impressed vibrations) a position of maximum purity and loudness is reached. At greater distances the reproduction by the jet becomes at first rattling and harsh, and finally unintelligible. In the latter case the jet will be seen to break above the membrane.

From this experiment we may draw the conclusions previously arrived at for air-jets; viz., that all changes produced by sound at the orifice grow in accordance with the same law; and that all changes travel with the same velocity, which is probably the mean velocity of the stream.

The mode in which the jet acts upon the membrane becomes apparent when instantaneous shadow-photographs of vibrating jets are examined. When the jet is steady, and the orifice strictly circular and well insulated, the outline in the upper part of the stream is that of a slightly conical rod, the base of the cone being at the orifice. When, however, vibrations are impressed upon the support, swellings and constrictions appear on the surface of the rod, which become more pronounced as the fluid travels downwards. At the breaking-point the constrictions give way, those due to the more energetic sound-impulses being the first to break. When the impressed vibrations are complex, the outline of the jet may be very complicated. When the membrane is interposed, we have then a constantly changing mass of liquid hurled against it, and vibratory movements are therefore excited in it, proportional to the varying cross-section of the jet at its surface.

It would appear at first sight that the mode of growth of the vibratory changes in a liquid jet must be different from that which characterizes the vibrations of an air-jet. It is possible, however, by special arrangements, to receive the impact of only a small section of a vibrating liquid jet, and thus to get a reproduction of its vibrations as sound. We are thus led to conclude that the sound-effects of a vibrating liquid jet may not be simply due to its varying cross-section, since actual changes occur in the translation- or rotation-velocity of its particles. Experiment shows that these changes are greatest along the axis of the jet.

One of the most interesting and beautiful methods of studying the vibrations of a jet consists in placing some portion of it in circuit with a battery and telephone, whereby its vibrations become audible in the telephone. A number of forms of apparatus for this purpose have been constructed, but one will serve as a type. Savart, in the course of his experiments, showed that the vibrations of the jet are preserved in the 'nappe,' or thin sheet of fluid formed when the jet strikes normally on a small surface. So far, then, as vibratory changes are concerned, the nappe has all the properties of the main stream. Although the diameter of this excessively thin film is about the same whatever be the distance of the surface

from the orifice, the intensity of the vibratory changes propagated to it varies with this distance, as for the jet itself. It is simply necessary, then, to insert into the nappe two platinum electrodes in circuit with a telephone and a battery having an electromotive force of from twelve to thirty volts, to get an accurate and faithful reproduction of the jet-vibrations. Loud sounds can thus be obtained from a jet which is finer than the finest needle, and the arrangement constitutes a highly sensitive 'transmitter' (figs. 7 and 8).

A jet-transmitter, in its simplest form, consists essentially of a glass jet-tube which is rigidly attached to a sound-board, and supplied from an elevated reservoir containing some conducting-liquid (distilled water acidified with one three-hundredth of its volume of pure sulphuric acid is the best), and a couple of platinum electrodes embedded in an insulator, such as ebonite, against which the jet strikes. The jet may issue from a circular orifice, about 0.25 mm. in diameter, in the blunt and thin-sided end of a small glass tube. Much smaller jets may be used, but, for one of the given size, the pressure required for distinct transmission of all kinds of sounds will not exceed thirty inches. The receiving-surface is the rounded end of an ebonite rod, through the centre of which passes a platinum wire. The upper end of the rod should be about 1 mm. in diameter, and should be surrounded by a little tube of platinum; and the end of the central wire and the upper margin of the tube should form a continuous slightly convex surface with the ebonite, free from irregularities. The inner and outer platinum electrodes are joined respectively to the terminals of the circuit. The jet is allowed to strike on the end of the central wire, and, thence radiating in the form of a nappe, comes into contact with the tube, thus completing the circuit. The dimensions of the apparatus may be varied to suit jets of different sizes; it is highly desirable, however, that the jet nappe should well overlap the inner margin of the ring-shaped electrode.

With small jets the impact disturbances are so feeble, that slight precautions are necessary to insulate the receiving-surface from the orifice, unless the former is placed low down in the path. The strength of battery may be increased until the escape of electrolytic gas-bubbles causes a faint hissing noise in the telephone. The liquid, on its way to the jet, should pass downwards through a wide tube lightly packed with coarse clean cotton, by which minute air-bubbles which violently disturb the jet, and small particles of dust which might obstruct the orifice, are stopped. This tube should never be allowed to empty itself.

Experiments are given to show that in this instrument the jet may act upon the electric current in two ways: first, by interposing a constantly changing liquid resistance between the electrodes; and, second, by causing changes in the so-called 'polarization' of the electrodes. In one form of instrument, namely, that in which both jet and electrodes are entirely immersed in a mass of liquid of the same kind as the jet liquid, the action must be entirely at the surface of the electrodes.

In the latter case a liquid jet becomes similar in structure and properties to a jet of air in air, and the velocity at different points when it is steady and when it is disturbed varies in precisely the manner already described.

The author briefly passed in review the leading facts to be accounted for, and laid stress upon the parallelism of the properties of gaseous and liquid jets. Some shadow-photographs of vibrating smoke jets have shown that these also present drop-like swellings and contractions which grow along the jet-path. The most satisfactory explanation of the phenomena will then be one which refers the vibratory changes in jets of both kinds to the same origin.

The beautiful and well-known experiments of Plateau have supplied a satisfactory explanation of the normal vibrations of a liquid jet in air. He has shown that a stationary liquid cylinder, whose length exceeds a certain multiple of its diameter, must break up, under the influence of the 'forces of figure,' into shorter cylinders of definite length, which, when liberated, tend to contract into drops. Now, the jet being regarded as such a stationary cylinder, we have a satisfactory explanation of the musical tone resulting when its discontinuous part strikes upon a stretched membrane, and when the impact disturbances may be in any way conducted back to the orifice. These disturbances then accelerate the division of the jet after it leaves the orifice. Plateau endeavored to show that division of the jet might take place at other than the normal points, thus explaining Savart's conclusion that a jet can vibrate in sympathy with a limited range of tones. Lord Rayleigh, moreover, has recently shown that the inferior limit of this range is not so sharply defined theoretically as Savart's experiments would prove it to be.

Both Savart and Magnus, however, describe experiments in which a water-jet, carefully protected from impact and other disturbances, does not exhibit the peculiar appearances characteristic of rhythmical division; and the author's experiments conclusively prove that this rhythmical division does not take place in a well-insulated jet. While the tendency so to divide may therefore be admitted, and the normal rate of vibration of the jet

and its greater sensitiveness to particular tones may thereby be explained, Plateau's theory cannot be held to account for the uniform growth, along the jet-path, of all changes, however complex their form; for this growth takes place independently of the 'forces of figure,' and under conditions in which they are entirely absent, as when a gaseous or liquid jet plays within a mass of fluid of its own kind.

The author is inclined, rather, to refer the properties of jets of all kinds to conditions of motion on which hitherto little stress has been laid; viz., the unequal velocities at different points in the stream after it has left the orifice. From the axis towards the circumference of a jet near the orifice, the velocity diminishes continuously, and the motions of the stream may be regarded as resultants of the motions of an infinite series of parallel and co-axial vortex-rings. In many respects, in fact, the appearance of a jet resembles the appearance of a vortex-ring projected from the same orifice. Thus a jet from a circular orifice, like a vortex-ring from a round aperture, remains always circular. In a frictionless fluid a vortex-ring, uninfluenced by other vortices, would remain of constant diameter, — a condition to which a horizontal liquid jet approximates. When, however, the ring moves through a viscous fluid, it experiences retardation and expansion, which are precisely the changes which a jet playing in a fluid of its own kind undergoes. The vibrating smoke-ring projected from an elliptical aperture changes its form in exactly the same manner as a jet, at sufficiently low pressure, from an elliptical orifice. These analogies might be considerably extended.

In a liquid jet in air or in a vacuum, internal friction must gradually equalize the velocities. At a distance from the orifice, therefore, depending on the viscosity of the liquid, such a jet must approach the condition of a cylinder at rest, and must tend to divide in accordance with Plateau's law. The rapidity with which drops are formed depends mainly on the superficial tension of the liquid. The length of the continuous column should therefore bear some inverse ratio to the viscosity and superficial tension of the liquid, — a view which is in harmony with the results of Savart's experiments, and some of the author's, in this direction.

Where the jet plays into a fluid of its own kind, the retardation and expansion which it experiences are mainly due to its parting with its energy to the surrounding medium. When, as a result of vibration, growing swellings and contractions are formed in it, this loss must be more rapid; and the jet therefore shows a diminution of mean velocity along the axis, which increases with the distance from the orifice.

Such being the conditions, it is evident that any impulse communicated to the fluid, either behind or external to the orifice, or to the orifice itself, must alter the vorticity of the stream. That vortex-rings are generated by impulses of the first kind is well known; the action when the orifice is moved is intelligible, if we consider that a forward motion of it will produce acceleration, a backward motion retardation, of the outer layers of the jet. As the result of a rapid to-and-fro motion, we may then imagine two vortex-rings to be developed; the foremost layer of greater energy, and moving more slowly, than the hindmost. These two rings, in their onward course, will then act on each other in a known manner: the first will grow in size and energy at the expense of the second, at the same time diminishing in velocity; the second will contract while its velocity increases. The inequalities in cross-section, initiated at the orifice, thus tend to grow along the jet-path, and will be attended also by growing inequalities of the normal and rotational velocities of the particles. Since the stream-lines of a vortex-ring are crowded together at its centre, the disturbances produced by impact of the jet-rings will be greatest along the axis, and least along the circumference.

Indeed, the sound disturbances produced by impact of a common vortex-ring are quite analogous to those of a vibrating jet. Let an air-ring be projected into a trumpet-shaped tube connected with the ear, and little more than a rushing noise will result; but let it be projected against a small orifice in the hearing tube, and a sharp click will be heard at the moment of impact. This click is loud when the centre of the ring strikes the tube, but faint, although still of the same character, when produced from the circumference.

The foregoing considerations may be extended to cases in which the motions of the orifice are complex vibrations. Expansions and contractions are then initiated in the fluid proportional at every point to the velocity of the orifice. The inequalities must tend to further diverge in the manner described.

Similar considerations apply to cases in which the motions of the orifice are the result of lateral impulses. In these cases the rings formed in the jet will not be perpendicular to its direction, and in their onward course may possibly vibrate about a mean position.

The author further pointed out how the viscosity and surface-tension of the fluid may influence its sensitiveness. When the surface-tension is very high, as in mercury, it produces a tendency in the

jet to break easily under the influence of moderate impulses.

The foregoing is ttle m ore than the outlines of a new theory of jet-vibrations. The author hopes to supply in the future further experimental evidence in support of it.

BOSTON LETTER.

EVIDENTLY one should join the Essex institute in Salem if one wishes to live to a green old age. This well-honored scientific body held its annual meeting recently; and the secretary's report showed, that, of the 24 deaths during the year, all but one were of persons over fifty years of age. Moreover, of the 324 living members, two-thirds are over threescore years and ten, and seven are past fourscore. The institute is soon to go into new quarters.

Preparations are making for the celebration at Cambridge of the two hundred and fiftieth anniversary of the founding of Harvard college. It will not take place at the commencement season, but at some time the following autumn, and it seems to be generally understood that Hon. James Russell Lowell will preside. It will be a different thing from the bicentenary, when a smaller audience-room than is now available permitted even all the undergraduates to find a place. The living Harvard alumni alone are probably three times the number living fifty years ago, and certainly the undergraduates are five times as numerous as then. This event makes specially appropriate the list just published by the university, showing the literary activity of its officers during the last five years. A similar ten-years list was published in 1880; but the present, though only for half that time, not only contains a longer list of publications than the former, but a somewhat larger number of writers among the officers.

Gifts continue to come in to the university. Mrs. Draper of New York continues to further the researches to which the late Dr. Henry Draper devoted his life. Her latest gift is of a thousand dollars to Harvard college observatory, to be expended under the direction of Professor Pickering in prosecuting researches in the photography of stellar spectra; the eleven-inch photographic lens constructed by Dr. Draper will be employed in this work, and those who heard Professor Pickering's account, at the Albany meeting of the National academy last autumn, of his own work in the field in which Dr. Draper's name is so honorably associated, will believe that Mrs. Draper has made an excellent choice.

In this same connection it should be mentioned that the contest at law about the Paine bequest to the Harvard observatory, mention of which has before been made in this correspondence, is happily closed by amicable settlement between the parties concerned. The amount which will now be turned over to the observatory, probably within the next month or two, will scarcely differ from that previously announced, and on the death of the widow it is probable that the entire bequest will exceed three hundred thousand dollars. Those who have followed the telling activity of the observatory under its present management will be confident that no other institution could make better use of such a noble gift.

At the annual meeting of the American academy, May 25, it was voted to present the Rumford gold and silver medal to Professor Langley of the Allegheny observatory, for his researches in radiant energy. Thus Professor Langley has in a single year borne off the two principal gold medals given for scientific work in America, having received the Draper medal of the National academy only last month. No one will dispute his right to them. The Rumford fund will also be used this year by the American academy in aid of researches upon the solar corona at the time of the total eclipse of August next, five hundred dollars having been appropriated in aid of Mr. W. H. Pickering's expedition to the West Indies. A letter was read from Mr. Greenough the sculptor, a fellow of the academy, announcing his gift to the academy of a portrait of Galileo, which he stated was either an old copy or a replica of the portrait in the Pitti palace. The portrait is already on its way to America.

In passing through Mount Auburn cemetery the other day I observed for the first time the monument which has been erected at the grave of Pourtalès, the colleague of Agassiz, and the pioneer in the zoölogy of the deep seas. It is a simple but massive semicircular slab of very fine-grained sandstone, on one face of which is the usual inscription, while on the other, facing the grave, has been deeply engraved a conventionalized Pecten-like sea-shell, forming a sort of niche; and on the surface of this are neatly sculptured in bas-relief a coral, a Comatula, a Gorgonia, and a magnified foraminifer, emblematic of the subjects of his study.

Ths topographical field-parties of the U. S. geological survey have begun their season's operations in this state, and before next winter most of the field-work will have been finished. The Appalachian mountain club, taking advantage of the work already completed, is about to issue, by permission of the survey, a photolithograph of a portion of the field-sheets on the original scale, comprising the extreme north-western corner of

the state, with Greylock, our highest mountain mass. Contours will be shown twenty feet apart, and bring out in fine relief the bolder slopes of this part of the state. Y.

Boston, June 1.

NOTES AND NEWS.

THE Imperial university of Japan (Teikoku-Daigaku), founded by imperial decree of March 1, 1886, includes the two institutions formerly known as the Tōkyō university (Tōkyō Daigaku) and the Imperial college of engineering (Kobu-Daigakko), these institutions having ceased to exist. The university comprises five colleges, each with its own director; and at its head is the president, Hiromoto Watanabe. The secretary is Kiuichiro Nagai. The directors of the different colleges are: College of law (Hōka-Daigaku), the president (*ex officio*); College of medicine (Ika-Daigaku), Prof. Hiizu Miyake; College of engineering (Kōka-Daigaku), (acting) Prof. Dairoku Kikuchi, M.A. (Cantab.); College of literature (Bunka-Daigaku), Prof. Masakazu Toyama; College of science (Rika-Daigaku), Prof. Dairoku Kikuchi, M.A. (Cantab.). All communications to the Imperial university, whether on its own behalf or as the representative of the two above-mentioned institutions now defunct, should be addressed to the president; communications to the colleges, to the director of each college.

— Dr. Charles Upham Shepard, well known for his collections in mineralogy, died at Charleston, May 1. For a considerable portion of his life he was identified with the South Carolina medical college, and aided greatly in giving that institution an honorable standing. He was also connected with Amherst college; and to this college he gave his vast collection of minerals, which was unfortunately destroyed in 1880.

— A note from Dr. Hyde of Honolulu, to the *Missionary herald* for June, reports that "news has just come that on March 6 the bottom fell out of the volcano, and that Kilauea is now only a black hole in the ground; no lava, no fire, to be seen. But such phenomena have been seen before; and the wonderful crater may fill up again, and be active once more. There were forty-nine earthquakes on the island of Hawaii at the time, and probably some new vent opened for the subterranean fires."

— The house committee on commerce has reported favorably the bill providing for an expert commission to visit Mexico, Brazil, Cuba, and the Central American states for the purpose of investigating the merits of the methods pursued by Drs. Freire and Carmona for the prevention of yellow-fever by inoculation. In their report the committee say, "Dr. Carmona states, that in one series of observations during the prevalence of yellow-fever, of three hundred and eighty persons protected by inoculation, less than three per cent contracted the disease; while under the same circumstances, of one hundred and seventy-five persons not inoculated, thirty-two per cent were seized with it. He also states that seventy-six inoculated soldiers marching from Vera Cruz to Acayucan were joined by a soldier who had not been inoculated. Upon their arrival at the latter place, the unprotected soldier was seized with yellow-fever, and died, while no case of the disease occurred among his seventy-six comrades. Other facts of a similar character are related by Drs. Carmona and Freire, which certainly tend very strongly to show the success of this preventive treatment. It is therefore important that further scientific observations and experiments should be instituted in order to establish beyond controversy the facts relating to this subject, so vital to the interests of sanitary science, commerce, and humanity."

— The following assignments have been made in the topographical department of the geological survey: Mr. Mark Kerr is in Oregon; Prof. A. H. Thompson is in charge of the western division, with headquarters at San Francisco; Mr. Renshaw will be sent to Kansas and Missouri this week; and Mr. Richard Goode will go to Texas.

— The announcement of the death of Von Ranke was succeeded by that of George Waitz, one of his most painstaking and industrious pupils. Professor Waitz was born at Flensberg in 1813. He became professor of history at the University of Kiel in 1842, in 1848 he was a member of the Frankfort assembly, and in 1849 he was called to Göttingen. Waitz succeeded Pertz as editor of the 'Monumenta Germaniae historica,' and in connection with this work he has achieved a considerable reputation. His most important writings are, 'Deutsche verfassungs-geschichte' (2d ed., 1865, 4 vols.), Schleswig-Holstein geschichte' (1851-54, 2 vols.), 'Grundzüge der politik' (1862), and 'Die formeln der deutschen königs- und der römischen kaiserkrönung vom 10 bis zum 10 jahrhundert.' Of late years Professor Waitz has resided in Berlin.

— Pending the action of the appropriation committee, no instructions can be issued by the coast survey to continue work after June 30. As soon as the appropriations are available, preparations will be made to organize parties for field-work after July 1.

— Mr. R. M. Bache has been ordered by the coast survey to continue the topographical work on the south-east shore of Staten Island, and on the south side of Raritan Bay towards Sandy Hook ; Mr. F. W. Perkins is daily expected from his field-operations on the coast of Louisiana.

—Velhagen & Klasing (Leipzig) have begun the publication, in twelve monthly parts, of a new edition of Andree's 'Allgemeiner handatlas.' It will contain a hundred and twenty maps.

— The following works of interest to scientific readers have been lately announced : 'Earthquakes and other earth movements,' by John Milne (New York, *Appleton*) ; 'A manual of mechanics,' by T. M. Gordon (New York, *Appleton*) ; a work on the labor question in America, by Professor Ely (New York, *Crowell*) ; 'Photo-engraving processes,' by A. F. W. Leslie (New York, *Fuchs & Lang*) ; 'The flow of water through pipes and open conduits and from weirs and orifices,' by H. Smith, jun. (London, *Trübner*) ; 'The world as will and idea,' vols. ii. and iii., by A. Schopenhauer. tr. by R. B. Haldane and J. Kemp (London, *Trübner*) ; 'The Indian empire : its history, people, and products,' by W. W. Hunter (London, *Trübner*).

LETTERS TO THE EDITOR.

**** Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

A national zoological garden.

IN 1870 an act of incorporation was passed, establishing a zoölogical society in Washington ; but during the last sixteen years little or nothing has been done towards carrying out what the charter of this society provides for, or taking any steps in the direction of putting into effect the chief objects such an organization would have in view.

We learn from *Science* (vii. No. 160) that the public-spirited and venerable exhibiter of animals, Mr. P. T. Barnum, now comes forward and says, that, if congress will grant him thirty acres of the reclaimed flats on the Washington side of the Potomac River, he will expend the generous sum of two hundred thousand dollars in starting a national zoölogical garden.

Now, the eastern extension of these flats is not far from the Smithsonian grounds, and, taking every thing else into consideration, there is probably not a better site in this country for this particular purpose. The incalculable advantages that would be the outcome of such an establishment can be easily appreciated ; and it is only to be hoped that at an early day congress will take Mr. Barnum's proposition into favorable consideration.

Few institutions in any country afford better educational advantages than a large, well-kept, and well-managed zoölogical garden. No better proof of this can be brought forward than the report of Mr. P. L. Sclater, F.R.S., secretary of the Zoölogical society of London, for the year ending 1885. Mr. Sclater tells us that during the year quoted, 659,896 persons visited the gardens, and that the receipts of the society amounted to the extraordinary sum of £25,809 10s 1d ; while during the previous year 745,460 persons visited the gardens, and the receipts were proportionately greater ; in fact, £3,129 more.

Many of the larger animals in this country are now rapidly disappearing from off the face of the earth, — notably the bison, the elk, and moose, —while numbers of the smaller representatives of our splendid mammalian and avi-fauna are unfamiliar to the eyes of the vast majority of the people of this country, from the simple fact that we are so poor in institutions where the living specimens can be put on exhibition.

Mr. F. W. True, curator of the department of mammals in the Smithsonian institution, points out in *Science* (vii. No. 171) another deplorable neglect, which unfortunately we are likewise guilty of, and which the establishment of a zoölogical society in Washington would do much towards rectifying. With the disappearance of our larger animals and other vertebrates, the opportunities are forever being placed beyond our reach, to intimately know about the anatomical structure of these very forms. In regard to this, anatomists are too apt to say something like this : "Oh, yes ! a prairie dog ; no doubt its organization is very much like the squirrel's, and will not repay exhaustive examination." Now, I say that these related and interrelated types are the very ones that will repay the most exhaustive research.

A competent prosector attached to our zoölogical garden — one who combined the qualities of an artist, an author, and a general anatomist — would soon demonstrate the high importance of his work, and contribute the most efficient aid to animal taxonomy. The brilliant productions of Garrod and Forbes, in the Proceedings of the Zoölogical society of London, speak volumes in favor of this advantage.

A share of the pecuniary receipts that would accrue from such an establishment could be set aside to meet the expenses following the publication of handsomely illustrated memoirs, giving large colored plates of the rarer acquisitions to the gardens, and the investigations of the prosector into the structure of such animals as died from time to time, and thus fell into his hands. We have long felt, in this country, the need of just some such standard publication as the excellently conducted Proceedings of the Zoölogical society of London ; and this would certainly be realized, and follow as one of the natural results pending the establishment of our national zoölogical garden. R. W. SHUFELDT.

Fort Wingate, N. Mex., May 26.

Scent-organs in some bombycid moths.

At intervals during the past year or two, isolated observations have been made of peculiar filamentary processes protruding from the abdomen of the male of some of our common bombycids, Leucarctia acraea and Scepsis fulvicollis being the observed species. Not long since, I described a peculiar abdominal character in the male of Cosmosoma omphale ; and the recent capture and examination of specimens of Leucarctia acraea has enabled me to add something to the knowledge of the structure in that species. Between the seventh and eighth ventral segments is a narrow opening, entirely invisible in the dried insect, but readily discerned on a

slight pressure of the abdomen in the fresh specimen. This opening extends back about an eighth of an inch, and, on being carefully pried open, shows two closely folded tufts of fine blackish hair. Pressure upon the abdomen will generally force out these tufts, and, if rightly applied, will result in the extension of two orange tentacle like structures, fully half an inch in length, united at the base, and spreading backward and outwardly in a gentle curve. The tufts of hair diminish as the tentacles are extended, the individual hairs occupying small but distinct papillae on the sides, until, when fully extended, they are evenly distributed around them, and no trace of the brush-like tuft remains. If the pressure be removed, the tentacles contract, the hairs again forming a tuft.

Specimens of Pyrrharctia isabella, when closely examined, showed a similar abdominal structure; but here there were four tufts extended instead of two, and in color they were snow-white. Properly applied pressure resulted in the inflation, first, of two basal sacs, which, when fully dilated, could be compared to nothing better than the ends of two thumbs pointing in opposite directions, the hairs of two of the tufts arranged rather densely on the convex outer surface. From the middle of the lower edge of these sacs there extended two tentacles similar to those in acraea, but not so long; and instead of being evenly clothed with hair, in this species the lower portion only has the papillae and hairy surface. The sacs and tentacles here are whitish, instead of orange, as in acraea. The processes of the latter species have a most remarkable resemblance to the tentacles of the larva of the common Papilio asterias, both in color and in shape. In both species an intense odor, somewhat like the smell of laudanum, is apparent when first the tentacles are exposed; and there is no reasonable doubt but that they are odor-glands, though exactly what purpose they serve is not so clear. In closely allied species no trace of this structure has been detected. Several fresh specimens of Arctia, Spilosoma virginica, and Hyphantria textor showed no trace of it; and no dry specimens of any other species thus far examined have a similar structure.

JOHN B. SMITH,
Assistant curator.

U. S. national museum.
Washington, D.C., May 28.

Muscles of the hind-limb of Cheiromeles torquatus.

I desire to place on record some observations I have recently made on the muscles of the hind-limb of Cheiromeles torquatus. This bat is one of the most interesting of the Cheiroptera. It is to a great extent arboreal in its habits. The wings are small, the body heavy and uncouth, and the wing-membranes are so arranged as to accommodate the young within a pouch on the back instead of on the front of the chest, as is the case in most of the bats. As a consequence, I expected to find in the musculature of the hind-limbs structures recalling those of other orders of mammals rather than those of the bats generally. In the main these anticipations have been met. It has always been supposed that the popliteus, the biceps, the soleus, and plantaris muscles are absent in the bats. It is true that Macalister finds in Vampyrops a few oblique fibres 'like a rudimental popliteus,' and Humphry identifies a small fascicle in Pteropus as biceps; but with these exceptions, as Macalister says, "there is no trace of biceps, popliteus, soleus, or plantaris in any." There is no doubt that the popliteus, the biceps, and the plantaris are present in Cheiromeles. The soleus is the only one of the absentees which is unaccounted for.

The maintenance of this group of muscles in a bat which is specialized for a tree-life, and scurries about the trunk after a fashion much like that of Pteromys, suggests the conclusion that the muscles named (excepting the soleus) are essential to the simplest expression of a true act of walking. They are absent in the volant bats, since they are of no use in flight; but they at once re-appear when the limbs are used for walking, or for the movements which are similar to this act. The assumption here taken that Cheiromeles is a true bat, which has been specially modified from the typical bat, is, I believe, tenable, and need not be here discussed. Occasion will be taken in due time to present arguments to sustain it. I will be content now to record the existence of the muscles named, and to give brief descriptions of them.

The popliteus is a well-defined muscle which slightly overlies the origin of the tibialis posticus. It does not create an oblique line on the tibia, which is so characteristic of the muscle in the mammals generally.

The plantaris is a conspicuous muscle, and is larger and heavier than is the gastrocnemius. It is distinct from the gastrocnemius its entire length. The muscle passes down to the sole of the foot, where it is continuous with the plantar fascia. Traction on the muscle flexes and abducts the foot.

A single muscular mass attached to the ischium represents the semi-membranosus and the biceps. The biceps becomes free at the upper fourth of the thigh, and is inserted into the head of the fibula.

The muscle which represents the tibialis posticus and flexor longus digitorum arises from the upper part of both the tibia and the fibula. It remains fleshy until it reaches the neighborhood of the tarsus, when two distinct tendons appear. One of these may be said to represent the flexor longus digitorum. It passes superficially over the ankle, and is lost on the plantar surface. Traction on the tendon abducts the foot, but does not flex the toes. The tendon of the tibialis anticus is lost on the tarsus. Traction on this muscle exerts no apparent influence on the movements of the tarsus.

HARRISON ALLEN.

Philadelphia, May 25.

Double vision.

In your issue of May 14, p. 440, Mr. Keller describes some phenomena of binocular vision, and asks an explanation. It would be impossible to do this in a short communication, but he will find the subject explained in any work on binocular vision. Perhaps the most accessible to him is my own little volume, entitled 'Sight' (International scientific series, vol. xxxi.). For explanation of phantom images, I would refer him to the chapters on 'Single and double images,' and on 'Superposition of external images,' and especially to the diagram on p. 116; and for explanation of inequalities of surface of such images, to p. 141 and preceding pages.

JOSEPH LECONTE.

Berkeley, Cal., May 24.

SCIENCE.—SUPPLEMENT.

FRIDAY, JUNE 4, 1886.

AN INDIAN SNAKE-DANCE.[1]

THE worship of the serpent has been so closely connected with the mythologic systems of so many primitive peoples, and has exercised so large an influence on religion, that any facts bearing on the subject must be of interest. It has even been said that this form of worship was more widely and universally distributed than any other. In Egypt, at the dawn of history, serpent-worship had already assumed the highest importance. Among the Phoenicians and in ancient Persia the serpent was worshipped as an evil deity, and also at a later period among the German tribes of the north; and the same myth may be traced in a modified form in the legendary history of the Greeks and Romans. Among the Hebrews there existed a strong tendency to this form of worship, — a tendency which, though repeatedly crushed out by the hand of power, as often re-asserted itself; and so late as eight hundred years after Moses it was prevalent in one of its grossest forms, for we read in 2 Kings xviii. 4, "He removed the high places, and brake the images, and cut down the groves, and brake in pieces the brazen serpent that Moses had made: for unto those days the children of Israel did burn incense to it." With the Chinese the serpent is a "symbolic monster, dwelling in spring above the clouds to give rain, and in autumn under the waters." It is in this connection, i.e., in connection with rain, that the performance that I am about to describe, occurred. In India the serpent was regarded as the great evil spirit, and Krishna is represented as crushing its head beneath his heel.

To come nearer home, the myth was very widely distributed among the North American tribes at the time of the discovery, in many of them in the form of pure ancestor-worship, but in others not so connected. It was common among the mound-builders, as is shown by the number of mounds of the serpent-form still existing, and by the prevalence, in mound relics, of more or less conventionalized representations of the rattlesnake. A recent report of the bureau of ethnology contains illustrations of a number of shell-gorgets, described and figured by Mr. W. H. Holmes, which are engraved to represent snakes.

Nowhere, I think, was the influence of this myth more pronounced than in ancient Mexico; and nowhere, I may add, is it more involved or its meaning more obscure. As the tendency of modern investigation is to show the existence of a remarkable similarity between the ancient Mexican civilization and the pueblo system of our own south-western territories, any facts in regard to serpent-worship among the latter must be of especial interest.

During the early part of the past field-season we were engaged in the investigation of some ruins near the Moki Pueblos, and were so fortunate as to be in that neighborhood at the time of the 'snake-dance' of those Indians. We witnessed this interesting performance twice, — once at Mashongnavi, one of the middle towns of the Moki confederacy, on the 16th of August; and again on the next day at Wolpi, one of the eastern towns. The two dances are essentially the same, the only difference being in the greater number of performers at Wolpi, and in the painting of the body. I have selected the Mashongnavi dance for description, because it has never been described, and had never, to my knowledge, been seen by whites before our visit; while that of Wolpi has been witnessed by many interested persons, several of whom have published, or are about to publish, their accounts.

During several days, before the date fixed for the dance, we frequently met parties of Indians hunting for snakes. The men were perfectly naked, with the exception of the breech-cloth, and each one carried a long red buckskin bag to contain the reptiles, and a feather wand, described later on. As the dance occurs in August, when the temperature during the middle of the day is almost unbearable to a white man, the airy costume of the hunters is a decided advantage to them. Several hunters carried forked sticks.

The snake-hunting occupies four days, one day being devoted to each of the cardinal points of the compass. There is said to be also a supplementary search on the last day, in order to capture any snakes that may have been overlooked previously. About noon of each day groups of hunters visited the several springs lying in that day's section, in order to bathe and rest themselves, and to deposit in crevices in the rocky wall of the spring or reservoir a *baho*, or prayer-stick, — a small round piece of wood half an inch or less in diameter and three or four inches long, generally painted in green and white, and with a feather from the

[1] Read before the Washington anthropological society.

breast of an eagle attached to it. These *bahos* are prayers to the gods that the springs where they are deposited may not dry up, but continue to give an ever-increasing supply. We never saw the ceremony of depositing *bahos*, if ceremony there be, though on several occasions we reached the spring while the hunters were there.

At the end of each day the serpents collected during that day were deposited in an *estufa* situated on the southern edge of the village, the westernmost of a group of three. These *estufas*, or, as the Indians call them, *kivas*, were underground, or partly underground, chambers, a number of which are attached to each village, and form a kind of combined church and court-house, in which is transacted all the religious and civil business of the tribe. They are of various dimensions. Those mentioned here are about twenty-five feet long by twelve in width, and nine feet high. Most of these *kivas* have a slightly elevated *dias*, or platform, occupying a little less than one-half of the ground space, generally the south end. On this platform the women and other spectators stand during the performance of those rites which they are allowed to witness. There were a number of young men who seemed to make this their headquarters during the period of preparation, living in the *kiva* entirely, except when out on a hunt. They usually sallied out during the forenoon, armed with the various paraphernalia before mentioned, and returned to supper or feasting a little before sundown. At one of our visits, on the day before the dance, we found the floor of the *kiva* strewn with buckskin sacks, some empty, others containing snakes; but the bulk of the snake-supply was contained in three large earthenware vessels inverted on a slight bed of sand on the floor. Each vessel had a small hole broken through the bottom, through which the reptile could be passed. These holes were closed by corn-cob stoppers. During the visit, a man brought in another pouch, and released on the floor two small rattlesnakes. The younger men of the band played with these, apparently from simple amusement or curiosity, as there was no ceremonial whatever. They handled the snakes without taking any special precautions to get a safe grip, even holding them occasionally by the middle of the body. After a while they were put into the jars with the others. While one of the snakes was coiled on the floor for a movement, a naked boy walked past it to the other side of the room, passing within six inches of the snake.

The easternmost of the three *kivas* is the snake-*kiva* proper. In this underground chamber, for several days preceding the dance, various rites and ceremonies were performed. On the lower portion of the floor was a peculiar altar, made of various colored sands spread on the floor, and surrounded by lumps of clay in which were stuck small upright sticks with feathers attached. This sand-painting on the floor represented a mass of clouds from which descended four variously colored figures representing either snakes or lightning, the sign for these being apparently the same. Both the clouds and the other figures were very much conventionalized. The colors used were yellow, blue, pink, black, and white. It is unnecessary here to describe the details of this so-called altar or its construction, as the type is already well known through the able descriptions of Dr. Matthews and Col. James Stevenson. I do not think the snakes appear in this *estufa* until immediately before the dance.

We reached the village of Mashongnavi shortly after four o'clock in the afternoon of the appointed day, and found that preparations had been made to hold the dance in the middle court, — an oblong space measuring about a hundred and fifty feet by thirty or thirty-five, and closed all around by houses, with the exception of the narrow passage-ways at the south end nearest the *kivas*, and a large passage on the north, which, however, was not used in this ceremony. Only a part of the available space of the court was utilized. The court had been swept clean; and near the middle, close up to the houses, on the western side, a small conical hut constructed of green cottonwood boughs had been erected. The diameter of the hut, on the ground, was about six feet; and the tops of the highest branches measured about thirteen feet from the ground, though the inside height was probably under five feet. On the east side, flush with the ground, was an opening about two feet and a half square, covered with a piece of buffalo-hide, smooth side out. A little before five o'clock three men dressed in the snake costume came through the narrow opening at the south end on a run. Each carried in his hand a small red buckskin bag containing sacred meal. They entered the hut one at a time, remaining inside a moment. Immediately after these men came two others, dressed also in the snake costume, carrying between them a medium-sized flour-sack nearly full of snakes. These were deposited in the hut, and the whole party returned through the passage by which they had entered. A moment later the procession of dancers filed into the court.

There were two costumes, — that of the antelope gens, under whose auspices the dance was performed; and that of the snake order, the performers. The legend of this dance is the legend of the first arrival of the Mokis at their present

habitat. The antelope gens were the first to arrive, and were guided to their present location by the snake-woman. The snake order was instituted to commemorate this event.

The costume of the antelopes was much more brilliant than that of the snake-men. Each of the former carried in his hand a small, round, T-shaped rattle painted in white and green, the top and edges being white. The fore-arm was covered with white cloth. Around the waist was a sash of cotton embroidered in red and green in geometrical patterns; and hanging down halfway to the knee was a kilt, embroidered in the same style, and, like the sash, woven of cotton. Each performer, both the antelopes and snakes, wore two or more strings of shell beads around his neck, and, suspended from them, a brilliant haliotis shell. When the performer did not possess such a shell, he wore in its place a small circular mirror, such as is furnished by the traders. The breasts and upper arms were decorated in pinkish-white clay, with the conventional snake design,—a zigzag line. Suspended from the back of the sash hung a coyote-skin, the tail of which just reached the ground. The legs, from the knee down, were painted with the clay before mentioned. They wore anklets of red and green worsted on the ankles; and the feet, in some cases were bare, and painted with clay, in others were shod in ordinary moccasons. There seemed to be no rule for the antelope-men. The faces of all the performers were painted black, from the line of the mouth down. Both parties wore a small bunch of red feathers in the hair.

The snake-men wore the same kind of beads and shells as the others. The painting of the body differed somewhat: instead of the zigzag line, they had triangular-shaped blotches of pinkish clay on each breast, and on the upper arms near the shoulders. On the upper arm also, on both sides, they wore bracelets of bark, painted white. The fore-arm was painted with clay. The kilt was of the same style as that worn by the others, but of a red color. Running around it horizontally was a conventionalized drawing of a snake in black and white. At the knee they wore the regular garter in use by all the Indians of this region; and attached to the right leg, just below the knee, was a rattle, formed of a tortoise-shell with attached sheep or antelope hoofs, which made a most dismal clanking sound whenever the wearer moved his leg. The leg, from the knee down, was painted with clay; and the feet were shod in moccasons of red buckskin, with an attached fringe at the top, all looking very new and bright. These performers also wore the wolf-skin.

The leader of the dance, or high priest, carried a buzzing-stick, which failed to work properly, however, and was soon discarded.

The antelope-men, some ten in number, came in first. They entered in single file, and marched around four times in an irregular circle, approaching the hut from the north. They then took up their positions on either side of the hut, facing out. The snake-men, about fifteen in number, then entered the court, marching in the same direction as the others had. As they passed the hut, they scattered some sacred meal, and stamped on a concealed board in front of the door. This board is buried in the ground, immediately in front of the door of the hut, and a hollow scooped out under the middle of it. Each performer, as he passes, scatters some sacred meal (which is a form of prayer), and stamps on this board, producing a loud, hollow sound. The object is to call the attention of the gods to the zeal of the performer, that he may be properly rewarded. By another version, if a dancer succeeds in breaking this board, which is nearly two inches thick, any wish that he may make for two succeeding years will be granted. As the same board is used continuously until it wears out, it must be occasionally broken. It is possible, however, that the man who gave me this version invented it.

After this stamping had been repeated four times, the snake-men formed a line, facing the antelopes, and about six feet distant from them. The antelopes then commenced a low chant, in which the snake-men joined. Occasionally the measure was changed for a few moments, and they made a gesture with the feather wands which each man carried in his right hand. The chant was kept up without intermission during the entire dance, and was accompanied by a peculiar rhythmical swaying motion of the body. When the feather-shaking had been repeated four times, the snake-men broke their line, and grouped themselves in front of the door of the hut. A moment later the group parted, and one of the performers appeared, holding in his mouth a snake. A companion (also a snake-man) joined him, passing his left arm over the first man's shoulder; and the pair passed around on the line previously pursued, with the peculiar step which, for want of a better name, is called a dance. The companion carried in his right hand one of the feather wands before referred to, consisting of two large feathers (said to be those of the wild turkey) mounted in a short wooden handle, with a small red feather dangling from the end. This wand was constantly and very skilfully used by the companion to distract the attention of the snake held in the mouth of the other, and to keep its head forward. The man who carried the

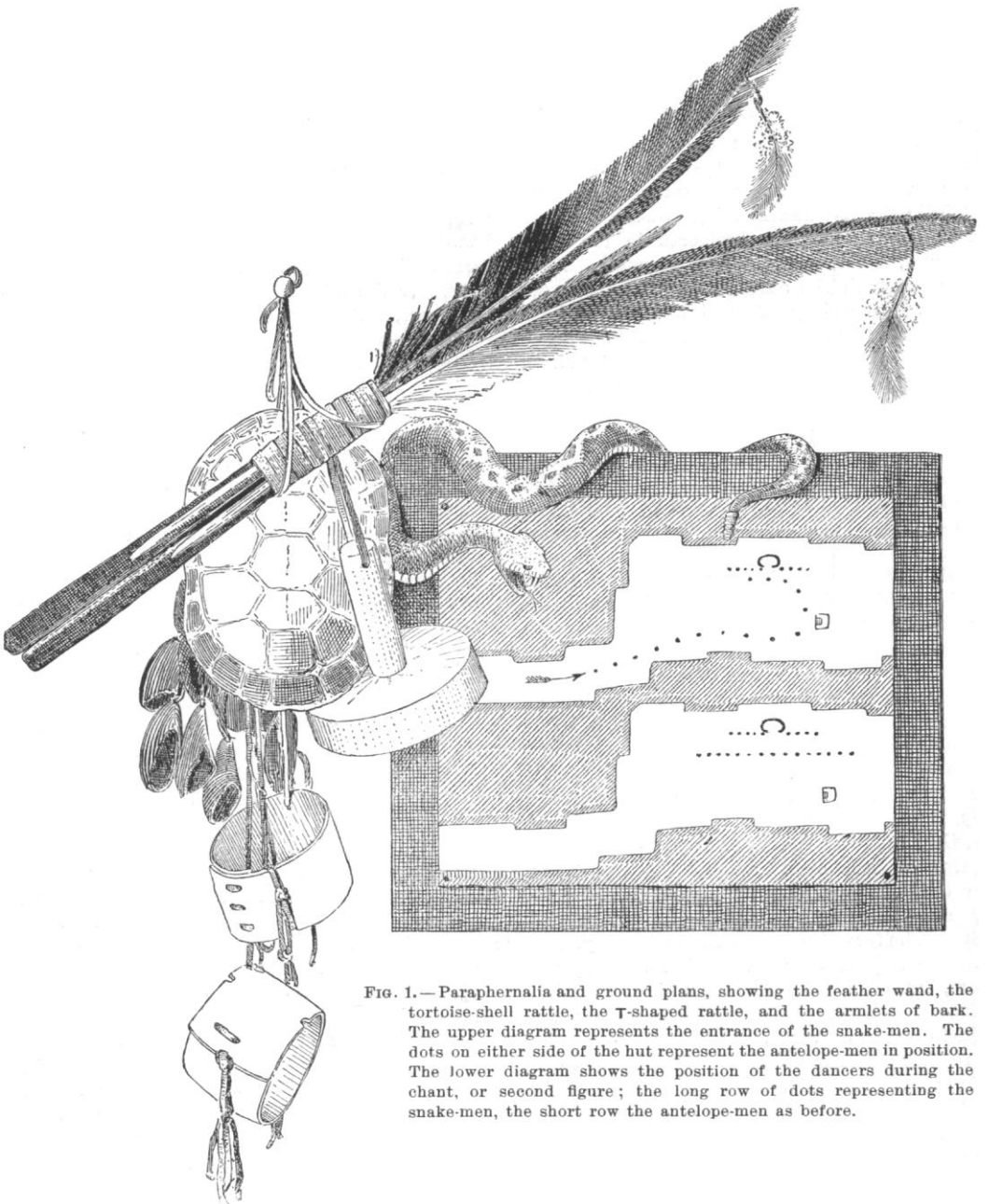


Fig. 1.—Paraphernalia and ground plans, showing the feather wand, the tortoise-shell rattle, the T-shaped rattle, and the armlets of bark. The upper diagram represents the entrance of the snake-men. The dots on either side of the hut represent the antelope-men in position. The lower diagram shows the position of the dancers during the chant, or second figure; the long row of dots representing the snake-men, the short row the antelope-men as before.

A SNAKE-DANCE AMONG THE MOKI INDIANS OF THE SOUTH-WEST.

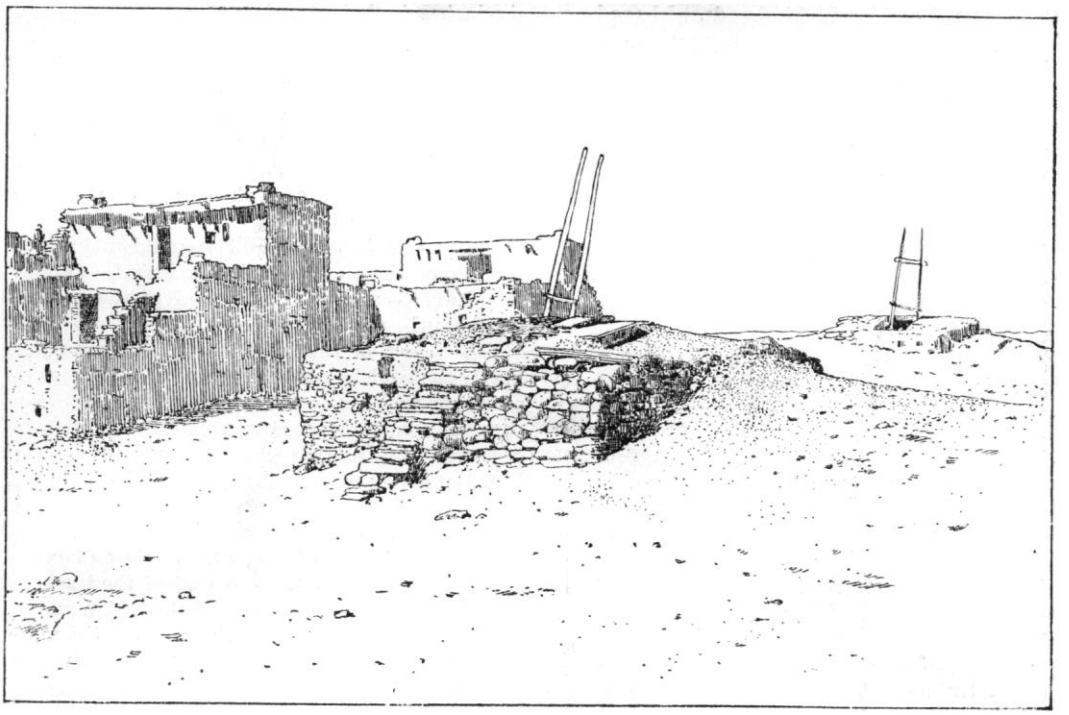


FIG. 2. — A MOKI KIVA.

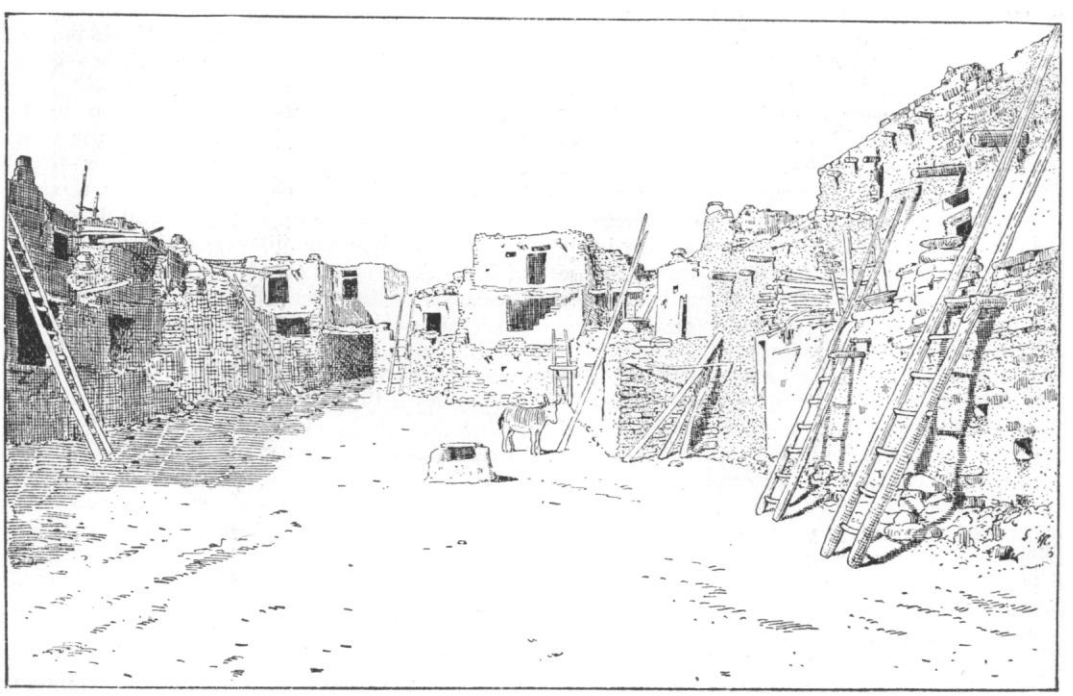


FIG. 3. — THE MIDDLE COURT OF MASHONGNAVI, LOOKING NORTH.

snake carried nothing in his hands. I have been told that the men who took this part kept their eyes tightly closed during the whole performance. This, however, I did not notice myself, though these dancers were always led back to the hut when it was desired to procure more snakes. The snake is held in the mouth between the lips, not between the teeth; and the mouth is filled with some substance, resembling meal in appearance, to avoid biting the snake when the dancer becomes excited. When a snake became unmanageable, the dancer simply opened his mouth, letting it fall to the ground.

Each of the couples described was followed by a single man or boy, whose duty it was to pick up the snakes as they were dropped. These also carried feather wands. I shall hereafter refer to these as collectors. As the snakes were dropped haphazard, at any place, and at any time, and as they manifested a lively disposition to get out of the way as soon as possible, the position was hardly a sinecure.

This second figure of the dance occupied about twenty minutes; though, after the first round, the order became somewhat broken, the collectors being grouped in the centre, and darting here and there after snakes, while the dancers pranced around in an irregular circle. Each performer, as he dropped his snake, was led back to the hut by the companion for a new one; and this continued until the supply was exhausted. The low chant of the antelopes, the dismal though rhythmical clank of the tortoise-shell rattles, the peculiar motion of the dancers, the breathless attention of the spectators, — all gave this part of the performance a weird character.

The latter part of the figure, when the snakes had accumulated in the hands of the collectors, and the dancers became excited, was very interesting. One of the collectors had a dozen or more snakes in his hands and arms. When the number became too great for proper management, part of them were turned over to the antelope-men, who remained in line on either side of the hut, and were held in their hands until the final figure.

The final figure was the most exciting. One of the performers, going a little to one side, drew in sacred meal a circle about thirteen feet in circumference. Two diameters at right angles were drawn, and another line passing obliquely through their intersection, representing the cardinal points and the zenith and nadir. The latter are expressed by the line drawn from north-west to south-east.

The chant suddenly ceased, and all those holding snakes made a rush for this circle, and dropped them into it. The snakes formed a writhing mass, nearly filling the circle longitudinally, and about six inches in height, so nearly as could be distinguished, as the whole figure lasted but a few seconds. The snake-men then literally threw themselves into the circle. Each man seized as many of the reptiles as he could, and made off with them at full speed, through the passage by which the procession had entered, and through the other opening; and the public part of the performance was finished.

The snakes thus carried off were taken down to the foot of the mesa, and there released. On our way back to camp we met several parties returning from the performance of this duty.

The object of this part of the ceremony, as nearly as could be made out from the various descriptions which we received, was this: the snakes were released at the four quarters of the earth in order that they might find a rain-god (whose form is that of a gigantic serpent), wherever he might be, and tell him of the honor which his children had done him, and of the urgent need of rain among them. This is symbolized in the circle and cross lines before mentioned. The part of the heavens from which rain came indicated the region where the god was at the time that he received the message. This helps somewhat to explain the reverence, we might almost say fondness, which the Moki feels for the snakes. The released snakes act not only as messengers, but also as ambassadors, to the rain-god; and a snake which had been well treated would present the Moki's prayer much more forcibly than one which had been roughly handled.

Snakes of all varieties procurable were used, including the rattlesnake, about twenty per cent of the latter. Many of them were numbed from long confinement and frequent handling, though when given a chance to escape, as when they were dropped on the ground, they showed decided signs of life. A great rivalry is said to exist among the dancers as to who shall handle the largest and finest rattlesnakes; but, I must confess, I failed to see it. On the contrary, there seemed to be a preference for a small, thin snake, not poisonous (the whip-snake, I think). Several of the dancers held two of these in the mouth, and one man even had three. When a man happened to get a rattlesnake, however, he did not seem to mind it much; though, when a snake of this variety was dropped by one of the dancers, the collectors did not show any great eagerness to pick it up. Several of these rattlesnakes were in a very ugly mood, and, when dropped, immediately coiled themselves, sounding their rattles, and showing a disposition to fight. These were not picked up quickly, as the others, but were given a wide berth by dancers and collectors alike. One of the elder collectors,

more skilful or more rash than the others, would then approach, and tease the snake with his wand until it struck, the blow being received on the feathers. This would be repeated until the snake became frightened and attempted to escape; but, as soon as it uncoiled, the collector would seize it with a quick movement of the hand from the tail toward the head, the snake being grasped by the neck. This movement is accomplished with lightning-like rapidity. The wand is retained in the hand; and the feathers, during the operation, cover the snake's head. After the seizure, however, it seemed to make little difference how they held the snake, holding it by the middle or tail as often as by the neck. No one was bitten at this dance; though at Wolpi, the next day, one of the young performers, a boy of eight, made the rounds with a rattlesnake fastened to one of his fingers. During the final scramble I lost sight of him, and was unable to discover what course of treatment he underwent, or whether he survived or not.

One of the striking accessories of the dance, are the groups of women in holiday attire, who stand along the walls and along the margin of the dancing-space, holding in their arms large trays of sacred meal, which they scatter on the performers and on the snakes as they pass. The boy who was bitten at Wolpi was almost covered with meal by these women.

At the second dance, at Wolpi, we were on the lookout for the after-proceedings, and had an opportunity of seeing a part of then. Immediately after the dance the women were seen coming in from all directions with baskets of *peki* or paper-bread, great quantities of wheat-bread or rolls, bowls of mutton-stew, and the various eatables which formed the Indians' holiday food. The quantity seemed sufficient for an army. These were sent down into the snake-*kiva*. In the mean time other women were scurrying along with great bowls of a brownish liquid with a very disagreeable smell. I followed several of these women around to the back of the pueblo, and there saw a number of the late dancers drinking this liquid, and vomiting most violently. I afterwards learnd from Weeki, the snake-priest, that this process continues for four days, — a period occupied in alternate feasting and vomiting. This is the so-called purification.[1]

[1] This is the way our interpreter translated it: It should be constantly born in mind, however, that the idea of purity — of moral goodness — is one which does not make its appearance until we get well along in the scale of development, to a point much beyond the position occupied by these Indians. The savage or barbarous mind recognizes no physical cause for phenomena. Poison, *as such*, is an idea which is wholly inconceivable; and death from that cause, from a snake-bite for example, would be attributed to some evil influence exerted by man, as in witchcraft or by a supernatural being, or to some mistake or omission in the incantation.

This number, 4, runs through the entire performance: four days are spent in collecting the snakes, — one day for each of the cardinal points of the compass; the dancers retire then to the *kiva* for four days, fasting and praying during the day, and eating only one meal, and that one after dark; on the fourth day of this period the dance takes place, and is followed by four days of purification and prayer; each figure in the dance, except the last, is repeated four times.

A description of the Moki snake-dance which occurred at Wolpi in 1881 has been published by Capt. John G. Bourke of the army, in his book 'The Mokis of Arizona.' This description differs in many important points from mine. It is true, we describe dances at different villages; but I have already said there was no essential difference between the two performances witnessed by us: in action the two dances were identical. As Captain Bourke's account is probably a close one, the ritual of the dance must have undergone many important changes in the period which elapsed between the dance witnessed by him and the one here described. The dance is performed under the auspices of the antelope gens or the antelope order, we were unable to determine which; but the men who handled the snakes belonged to the snake order, and not to the snake gens. I think that one of the requirements is, that all those taking part in this dance shall be members, either congenital or adopted, of the antelope gens, or order, whichever it may be. The snake gens has nothing to do with the dance; and, contrary to the opinion of Captain Bourke, it is not referable, I think, to ancestor-worship, at least not directly. It is not even serpent-worship, unless the word be taken in its widest sense, — the sense which includes not only serpent-adoration and reverence, but also serpent-symbolism. It is in this sense that I have used the word. The Moki Indian loves and reveres the snakes, and will never, unless under the greatest necessity, do them harm; but he does not adore them, nor sacrifice to them as he does to his gods, but uses them simply as the most appropriate messengers to the rain-god.

The underlying ideas which have given rise to this dance are, and must remain so long as our knowledge is in its present incomplete state, unknown. From the point of view of the great majority of the Moki Indians, it is simply an invocation, — a ceremony having for its sole purpose the procuring of rain; but the fact that there is an esoteric legend, one very jealously guarded, too, seems to point to another and a deeper signification. An investigation in this direction would probably result in throwing much light, not only

on this particular ceremony, but on serpent-worship in general. The rites connected with this form of worship have always been secret, — secret even in the tribe where it is found. And while the worship of the serpent has been associated with some of the highest conceptions of the barbarous and semi-civilized minds, — with, for example, the principles of reproduction and of the immortality of the soul among the Hindoos, and with the idea of divine wisdom among the Egyptians, — and while it has been so widely distributed, in one form or another, that there is hardly a nation or tribe which does not carry traces of it in its history, but little is known about its details or origin. The performance takes place every second year at the village I have named, and is ostensibly, as I have before said, for the sole purpose of procuring rain. I have been assured by several of the old men in Moki that this dance has never failed to do this; and, in fact in the present instance, it was preceded by several months of the dryest weather known in that country for years, and was succeeded, on the very day of the dance, by such copious and prolonged showers, that many of the Mokis lost their crops by washouts.

KOSMOS MENDELIEFF.

THE ARTICLE 'PSYCHOLOGY' IN THE 'ENCYCLOPAEDIA BRITANNICA.'

IN the eighth edition of the 'Britannica' the article on metaphysics covered seventy-four pages, and there was no article on psychology at all; in the ninth edition the article on psychology covers forty-nine pages, and that on metaphysics is reduced to twenty-three pages. This change in the apportionment of space to these two topics is a reflection of the change of base which has occurred in the study of the philosophical sciences within the last few decades. Psychology has become, or at least has plainly declared that it intends to become, strictly scientific; and metaphysics has withdrawn to a field of its own.

In an encyclopaedia article on such a topic the author has a bewildering choice of possible modes of treatment. The average reader, referring to an article on psychology, will perhaps expect a general statement of the results obtained in the different departments of psychological research, treated from a broad modern point of view, and perhaps some account of the history of past doctrines, and explanations of the similar topics. Such a reader will be disappointed in Mr. Ward's article on psychology. The article is a very puzzling one for a reviewer. To find fault with it, is simply to say that it is not the kind of an article which he himself would have wished for or have written, and, on the other hand, shows a neglect for the very learned and bright treatment which the subject receives at the author's hands. On the other hand, he cannot refrain from expressing the very unsatisfactory impression which the reading of Mr. Ward's work leaves upon him. In analyzing this disappointment, one would lay the blame either on the fact that the reader's expectation was wrongly founded, or that Mr. Ward had chosen to write an article which did not have practical utility as its chief aim, or more probable, perhaps, than either of the above two, that the present condition of psychology is reflected in this unsatisfactory, rather scattered treatment. Perhaps, after all, this is the real appearance of a cross-section of the science at the present moment.

Beginning with the argument that the peculiarity of psychology rests, not in its subject-matter, but in its point of view, he proceeds to develop a theory of presentations which is fundamental to his whole treatment. Then, under seven or eight headings, he treats such subjects as perception, imagination, association, feeling, self-consciousness. But under each section the reader finds himself at once *in medias res*. No general outline of the topic is given, or of its connection with other subjects. The author is evidently perfectly at home in the literature of the topics; but only here and there, by way of illustration, are the results of recent experiments in this field brought in. The section on feeling is recommended as especially well treated.

He then develops the theory "that there is pleasure in proportion as a maximum of attention is effectively exercised, and pain in proportion as such effective attention is frustrated by distractions, shocks, or incomplete and faulty adaptations, or fails of exercise, owing to the narrowness of the field of consciousness, and the slowness and smallness of its changes."

In a general review of this volume of the encyclopaedia a writer referred to the article as the most abstruse article in the volume. This abstruseness seems to come from the fact that the author has given a series of minute dissections, but neglected to give the relation of the different parts which were under the knife. He has used the microscope without describing the naked-eye appearances.

THE replacement of a diseased eye by the healthy eye of an animal has now been done five times, with one success, says the *Medical record*. In the four cases the cornea sloughed; in two however, firm vascular adhesions took place.